Oceanography Exercise 2b
CALCULATIONS AND CONVERSIONS

This exercise builds on the previous exercise on Powers of Ten, and familiarizes you with making scientific calculations including units and with conversions between different units. Before starting on this exercise, please read the overview of the metric system (p. 463) and use for reference Appendix I – Measurements and Conversions on pages 464-465 in your textbook.

Most scientists use SI Units (for Système International, which is the metric system) exclusively for measurements and calculations. However, because of tradition in the United States, we may have to convert between SI Units of **meters**, **grams**, and **degrees Celsius,** and "English" units of feet, pounds, and degrees Fahrenheit.

Some useful and interesting web sites related to metric units and conversions:
http://physics.nist.gov/cuu/Units/history.html A brief history of the International System of Units
http://physics.nist.gov/cuu/Units/units.html A list of all the fundamental SI units
http://www.megaconverter.com/Mega2/index.html An interactive conversion calculator

The metric system is organized in powers of ten, which makes the math much easier than conversions between English units (for example, ounces to pounds, or miles to inches).

The basic SI units can be modified by prefixes to express the powers of ten
(these are the prefixes frequently used by most scientists):

10^{12}	tera	T	10^{-1}	deci	d
10^{9}	giga	G	10^{-2}	centi	c
10^{6}	mega	M	10^{-3}	milli	m
10^{3}	kilo	k	10^{-6}	micro	µ
10^{2}	hecto	h	10^{-9}	nano	n
10^{1}	deka	da	10^{-12}	pico	p
			10^{-15}	femto	f

Think about computer mass storage: kilobytes = 1000 bytes, megabytes = 10^{6} bytes, gigabytes = 10^{9} bytes, terabytes = 10^{12} bytes (used on supercomputers).

And if you really wanted to know (things that astrophysicists use):

10^{24}	yotta	Y	10^{-18}	atto	a
10^{21}	zetta	Z	10^{-21}	zepto	z
10^{18}	exa	E	10^{-24}	yocto	y
10^{15}	peta	P			

A convenient feature of the metric system is that length, volume, and mass are all related.
1 liter of liquid water at 1° C has a mass of 1 kg
1 cubic centimeter (cm^3) of liquid water at 1° C has a mass of 1 g

Important Point – For a conversion or a calculation, if you get the units correct, you are probably doing the calculation correctly.

So what does that statement mean? (continued on the next page)

For example, converting between metric and English units.

Conversion factor: 2.2 pounds = 1 kilogram OR $\frac{2.2\ \text{lb}}{\text{kg}}$ (pounds per kilogram)

If you want to convert 7.5 pounds into kilograms, you divide (or multiply) what by what?

Set up the "equation" with the units that you have and the units that you want as a result:

$\text{pounds} \times \frac{\text{pounds}}{\text{kg}} = \frac{\text{pounds}^2}{\text{kg}}$ That's not the correct equation, so try

$\text{pounds} \div \frac{\text{pounds}}{\text{kg}} =$ Remember that dividing is equal to multiplying by the inverse (flip the units)

$\text{pounds} \times \frac{\text{kg}}{\text{pound}} = \text{kg}$ which is what you want. So the calculation is:

7.5 pounds ÷ 2.2 pounds / kg = 3.4 kg

1. Convert or calculate the following, and show how you did it:

a) 680 centimeters = ___________ kilometers

b) 31 inches = ____________ miles

c) the number of cubic centimeters (cm^3) in a volume of water that is

10 cm x 20 cm x 30 cm

Density is the mass per unit volume for any substance, and is usually expressed as grams per cubic centimeter (g / cm^3) or kilograms per cubic meter (kg / m^3). (We will work with density throughout the course.)

Calculate the mass in kilograms of one cubic meter of seawater, but do it in two steps. Assume that the density of seawater is 1.03 g / cm^3.

d) First, calculate how many cubic centimeters are in one cubic meter.
(and the answer is *not* 100 cm^3 – hint: how many centimeters are in one meter?)

e) Second, calculate the total mass in grams of the cubic meter of seawater, then convert that into kilograms. (Hint: how much mass is in each cubic centimeter of seawater?)

f) convert the mass that you calculated for e) above from kilograms to pounds

And just to make a point:

g) Calculate the volume of water, in cubic yards, of an area of the continental shelf that is 3.8 fathoms deep by 1.5 nautical miles x 2 nautical miles. (Use extra paper if needed.)

h) Calculate the volume of water, in cubic meters, of an area of the continental shelf that is 7.0 meters deep by 2.75 kilometers x 3.7 kilometers. (Which is approximately the same size as g) above.)

2. Express in scientific notation:

a) 186,000 miles per second

b) convert 2a) above to kilometers per second, express in scientific notation

c) 0.00125 meters

d) express 2c) above in an appropriate metric unit other than meters
(possibly centimeters or something similar)

e) for the last 800,000 years, glacial-interglacial cycles have occurred about every 100,000 years. Express 800,000 years and 100,000 years in units of ka (kilo annum = 10^3 years).
(Examples: 4,500 years = 4.5 ka 1,200,000 years = 1,200 ka or 1.2 Ma [mega annum])

Simple calculation, but show your math and the units – how many glacial-interglacial cycles have occurred during the past 800,000 years?

Rates – many of the measurements that scientists make are to calculate how fast (or slow) certain processes are happening; a rate is something per unit time.

An easily understood rate is the velocity (speed) of a vehicle. The rate in this case is distance covered in an amount of time. The general equation for velocity is:

R = D / T or Rate = Distance / Time

which can be expressed as miles per hour, miles per minute, feet per second, or
kilometers per hour, meters per second, centimeters per year.

The metric units for the above equation could be:

$\frac{cm}{yr}$ = cm / year which is appropriate for spreading of a mid-ocean ridge.

This general equation can be rearranged algebraically depending upon what measurements you have and what you want to calculate. The different forms of the equation are:

R = D / T   D = R x T   T = D / R

3. Rate calculations (show your math):

a) A car is traveling at 60 miles per hour (mph). How long does it take to travel 280 miles?

b) How fast is the same car going in feet per second?

c) During reentry through the upper atmosphere, the initial velocity of the Space Shuttle is 13,000 miles per hour.

Step 1: Convert this velocity to kilometers per hour

Step 2: Convert velocity in km/hr to meters per second

Step 3: Going that many meters per second, how long (time) does it take the Shuttle to cover 2000 meters (2 km) ?

d) The slowest spreading mid-ocean ridge is the Southwest Indian Ridge, just south of the tip of Africa. Spreading rates are typically 1.0 cm per year (but may be lower in certain sections). How much time does it take to produce 1 kilometer of new oceanic crust by spreading? Refer to p. 85 (6th ed., or p. 77 5th ed.) in the textbook for a visual image of seafloor spreading.

e) A paleomagnetic reversal that has an age of 890,000 years (before present) is identified 68 kilometers away from the axial valley of the East Pacific Rise in the direction of spreading. What is the spreading rate of the East Pacific Rise in kilometers per 1000 years, and in centimeters per year?

4. Areas and volumes – refer to Figure 3.6, p. 65 (or 5th ed. Fig. 3.5, p. 59) of your textbook.

Surface area of a sphere $SA = 4 \Pi r^2$ Volume of a sphere $V = 4/3 \Pi r^3$

a) The radius of the Earth is 6371 km. What is the total surface area of the Earth?
The oceans cover 71% of the Earth surface. What is the surface area of the world ocean?

b) The radius of the core is 3500 km. Assume that the thickness of the crust is negligible (less than 1%). The **core** is what percentage of the radius of the Earth? The **mantle** is what percentage of the radius of the Earth?

c) Calculate the **volume** of the total Earth, the core, and the mantle. The mantle makes up what percentage of the total **volume** of the Earth? {Important hint: you can't calculate the volume of the mantle by plugging 2871 km into the equation for volume of a sphere.}

5. Distances and travel times in space

Go to the website for the National Institute of Standards and Technology: www.nist.gov

First question, What does NIST do? What services does it provide for the nation?

(A short written answer.)

Second, find the "official" speed of light in a vacuum. [look on http://physics.nist.gov]

Write it down here.

Convert the speed of light from meters per second to miles per second. Show all the appropriate units. You will need this value to make the last calculation on this page.

Calculate the distance in kilometers and miles that light travels in one year (a *light year*). Show all the appropriate units.

Calculate how long it takes for light from the Sun to reach the following planets and dwarf planets:

[The nearest star is 4.22 light years away. Think of these distances as small fractions of a light year.]

Mercury

Earth

Saturn

Sedna

Distances of the Planets from the Sun in ***Miles***

Mercury	35,980,000	Jupiter	483,630,000	Pluto	3,675,000,000
Venus	67,230,000	Saturn	888,200,000	Sedna	8,333,000,000
Earth	92,960,000	Uranus	1,784,000,000		
Mars	141,640,000	Neptune	2,799,000,000		